The Afghanistan Engineering Support Program assembled this deliverable. It is an approved, official USAID document. Budget information contained herein is for illustrative purposes. All policy, personal, financial, and procurement sensitive information has been removed. Additional information on the report can be obtained from Firouz Rooyani, Tetra Tech Sr. VP International Operations, (703) 387-2151.

TETRA TECH

MEMORANDUM

To: [redacted] USAID

From: [redacted] P.E., Tetra Tech
[redacted] P.E., Tetra Tech

Date: November 15, 2011

Re: **WO-A-0081 K-K Bridge Calculations, Final Bridge Comments**

General

As requested by USAID, Tetra Tech (Tt) has reviewed "Concrete Girder Strength Design Check Calculations for Task Order 14, Bridge Nos. 09, 12, 13, 15, 23, 30, 42, 45 & [44], Kabul-Kandahar Highway," prepared by The Louis Berger Group Inc. / Black & Veatch Special Projects Joint Venture (Joint Venture), dated October 2011. This document contains some drawings; however a full set of drawings was not available during the review.

The original girder design of these bridges was based on concrete with a compressive strength of 45 MPa, but as-built concrete strengths resulted in minimum values ranging from 25 MPa to 30 MPa. The Joint Venture updated their original design calculations for the lower concrete strengths and determined the as-built bridges have adequate strength. The purpose of Tt's review is to verify the accuracy of the calculations and validity of the Joint Venture's conclusion.

It is important to note that during the Construction Phase, shop drawings / mill certs should have been submitted to USAID's representative for the beam reinforcement. As-built information regarding the beam reinforcement was not available during Tt's review. Therefore, Tt assumed that the reinforcement included in the Joint Venture calculations is consistent with the as-built condition.

Review of Girder Strength Calculations

The Joint Venture evaluated Bridges 13, 30 and 42 using the post-tensioned steel only (ignoring mild reinforcement) with a concrete compressive strength of 30-MPa.

The Joint Venture evaluated Bridges 09, 12, 15, 23, 44 and 45 as doubly-reinforced T-beams with a concrete compressive strength of 25-MPa.

Tt reviewed the calculations and noted specific comments on the attached spreadsheet. Since the comments "trickle through" the calculations, the magnitude of the effects of the comments on the results is not known. However, the comments generally either increase the load acting on the girders or reduce the girder capacity.

In is important to note that the Joint Venture used a combination of home-grown design templates (MathCAD, Excel) to analyze and design the bridge girders, rather than standard bridge design software. Tetra Tech's review included a detailed check of the input parameters, spot checking the analysis calculations and a detailed check of the design calculations. A detailed check of the analysis calculations was not feasible due to the schedule constraints of the Administrative Work Order and because electronic documents were not provided for review.

Our evaluation was limited to the review of a representative structure from each of the two distinct bridge types. A review of the presented calculations from the remaining structures confirmed that they are similar to those reviewed and that the Tt comments also apply to them.

Review of Design Check Conclusions

The design check calculations included a summary chart noting the required flexural strength and provided flexural strength for the girders of each bridge. This chart is summarized below.

It is important to note that based on Joint Venture's design, the girders are typically significantly overdesigned, with approximately three times the capacity that is required for the loads. The exceptions to this are Bridges 13, 30 and 42 (all post-tensioned), which have been designed to be nearly at 100% the required capacity.

Section	Strength, Mu (kN-m)		% Capacity
	Required	Provided	Used
09A	3188	9859	32%
09B	3188	9712	33%
12A	2182	7636	29%
12B	2182	7363	30%
13	***6207***	***6615***	***94%***
15A	2963	10005	30%
15B	2963	9964	30%
23	787	1157	68%
30	***6278***	***6615***	***95%***
42	***6159***	***6615***	***93%***
44A	3153	9228	34%
44B	3153	9090	35%
45A	2182	7636	29%
45B	2182	7363	30%

Since the reinforced-concrete bridges were over-designed, Tt anticipates that those bridges may have adequate capacity after Tt's comments are addressed. The three post-tensioned bridges, however, do not appear to have adequate capacity.

Additional Recommendations

Tt recommends that the Joint Venture review the attached comments, update the design calculations, and resubmit to USAID. The Joint Venture should consider including the mild steel reinforcement in the post-tensioned girder design to achieve additional capacity.

In addition, Tt recommends that USAID request that the Joint Venture provide recommendations for bridges which do not have adequate capacity based on the as-built concrete compressive strengths. These recommendations should include rating calculations to identify what vehicular live load can be supported by the bridges, so that USAID can post bridges for reduced truck loading, as required.

Design Review
Concrete Girder Strength Design Check Calculations for Task Order 14
dated October 2011
WO-A-0081

Response Legend
A - Agree
D - Disagree
O - out of scope
AE - Agree with exception

Comment #	Reviewer	Reference	Comment	Response Code	Response	Back-Check
STRUCTURAL COMMENTS						
Post-Tensioned Bridges - Comments are for Bridge No. 13. Other post-tensioned bridges similar.						
S-1	SAM	PDF Page 73 of 247	Resistance factors used are for steel structures, not concrete.			
S-2	SAM	PDF Page 74 of 247	Dist Factor (Int) - Distance (e_g) from center of beam to center of deck is not computed correctly. Using the correct e_g will result in increasing k_g which will in turn increase the interior beam distribution factor causing the applied factored moment M_u to increase in the same proportion.			
S-3	SAM	PDF Page 74 of 247	Dist Factor for Moment (Ext) - The lever rule calculation method is not applied correctly. Correct application will increase the distribution factor which in turn increases the applied factored moment M_u.			
S-4	SAM	PDF Page 74 of 247	Dist Factor for Moment (Ext) - The equation for “d_e” is not correct. This will increase the distribution factor which in turn increases the applied factored moment M_u.			
S-5	SAM	PDF Page 75 of 247	Dist Factor for Shear (Ext) - The lever rule calculation method is not applied correctly. Correct application will increase the distribution factor which in turn increases the applied factored shear V_u.			
S-6	SAM	PDF Page 75 of 247	Dist Factor for Shear (Ext) - The equation for “d_e” is not correct. This will increase the distribution factor which in turn increases the applied factored shear V_u.			
S-7	SAM	PDF Page 76 of 247	Non-composite DL - Exterior haunch weight is too low.			
S-8	SAM	PDF Page 76 of 247	Non-composite DL - Exterior SIP should be increased for the overhang.			
S-9	SAM	PDF Page 77 of 247	Load Combinations (load factor table) – Service II load combination should be considered.			

Comment #	Reviewer	Reference	Comment	Response Code	Response	Back-Check
S-10	SAM	PDF Page 83 of 247	In the "Analysis of Post-Tensioned Concrete Beam" presented, an initial f_{ps} is assumed according to AASHTO's section 5.7.3.1. Later f_{ps} is calculated and found to be greater than the initially assumed value. More iterations of this calculation should be performed until the value of f_{ps} converges.			
S-11	SAM	General	When comments S-1 through S-10 were implemented, we calculated a larger applied factored moment Mu than that provided in the presented bridge calculations.			
S-12	SAM	General	The calculations presented do not account for the sequence of bridge construction (which is performed in stages). The non-composite loads should be applied to the beams alone and the composite dead loads and live loads should be applied to the composite section.			
S-13	SAM	General	The beam's shear check/design is not performed in the presented calculations.			
S-14	SAM	General	Calculations for tendon stress losses are not included in the provided calculation package.			
Reinforced Concrete Bridges - Comments are for Bridge No. 09. Other reinforced concrete bridges similar.						
S-15	ALH	General	Resistance factors used are for steel, not concrete.			
S-16	ALH	General	Initial portion of calcs assume beam is a rectangle. Later portion of calcs go back and forth between rectangle and a t-beam. It is unclear if the inconsistency in the design assumptions will affect the results.			
S-17	ALH	PDF Page 8 of 247	Dist Factor for moment (Ext) - The equation for “de” is not correct.			
S-18	ALH	PDF Page 8 of 247	Dist Factor for moment (Ext) -The Lever rule does not appear to be used correctly.			
S-19	ALH	PDF Page 9 of 247	Dist Factor for shear (Ext) - Once “de” is updated, the lever rule should be used for subsequent calculations.			

TETRA TECH

Design Review
Concrete Girder Strength Design Check Calculations for Task Order 14
dated October 2011
WO-A-0081

Response Legend
A - Agree
D - Disagree
O - out of scope
AE - Agree with exception

Comment #	Reviewer	Reference	Comment	Response Code	Response	Back-Check
S-20	ALH	PDF Page 9 of 247	The equation used to calculate the skew correction (for shear) is not consistent with the given AASHTO reference.			
S-21	ALH	PDF Page 10 of 247	Non-composite DL - Exterior SIP should be increased for the overhang.			
S-22	ALH	PDF Page 11-14 of 247	Load Combinations (load factor table) – Service II load combination should be considered.			
S-23	ALH	PDF Page 18 of 247 (and throughout)	#11 bars were used to calculate the area of steel which is not the equivalent for metric 32 mm diameter bars. These calculations assume there is 22% more steel than is actual provided.			
S-24	ALH	PDF Page 19 of 247	Verify that the calculations for the spandrel effective width (be) are consistent with the referenced AASHTO equations.			
S-25	ALH	PDF Page 20 of 247	Verify the equations used to calculate xbal*d .			
S-26	ALH	PDF Page 21 of 247	Verify that there is no error within the cell that reads "!!! X balance.."			
S-27	ALH	PDF Page 22 of 247	Verify calculation used for fy.			
S-28	ALH	General	Verify the value used for f'c is correct. In some locations , f'c=3.6ksi is used, but in other locations f'c=4.0ksi is used.			
S-29	ALH	General	It appears the compression steel is not yielding. Verify all design assumptions are consistent with this condition.			
S-30	ALH	General	The calculations presented do not account for the sequence of bridge construction (which is performed in stages). The non-composite loads should be applied to the beams alone and the composite dead loads and live loads should be applied to the composite section.			
S-31	ALH	General	The beam's shear check/design is not performed in the presented calculations.			
S-32	ALH	General	For Bridge No. 23 specifically, design notes are based on pre-stressed reinforcement, but design is based on precast mild reinforcement. Please verify.			